Fw: Land Application of Biosolids Information and Report

Jocelyn Brennan to: cr_board_clerk Clerk Recorder 01/11/2016 04:28 PM

Cc: Adam Hill, Bruce Gibson, Debbie Arnold, Frank Mecham, Hannah Miller, Jennifer Caffee, Vicki Shelby, Cherie McKee

Sincerely,
Jocelyn Brennan
Legislative Assistant to Supervisor Lynn Compton
San Luis Obispo County, District 4

----- Forwarded by Jocelyn Brennan/BOS/COSLO on 01/11/2016 04:28 PM -----

From: Ted Peterson <ted.peterson@tcsn.net>
To: jbrennan@co.slo.ca.us
Date: 01/11/2016 10:08 AM
Subject: Land Application of Biosolids Information and Report

Hi Lynn:

Here is the report of a project I did for MBCWWTP. I have sent this to all the supervisors.

Supervisors:

You are contemplating land application of sludge (biosolids) in SLO county. We have had restrictions on the books for some time and I think that this project done in conjunction with the MBCWWTP can be important information in regards to your decision.

You can reach me for comments at:

Ted Peterson
Spirit of the Earth
e
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MorroBay.pdf

Item No. 15
Meeting Date: January 12, 2016
Presented by: Ted Peterson
Rec'd prior to meeting & posted to web on: January 11, 2016

City of Morro Bay & Cayucos

Biosolids and Green Waste Compost Project

Final Report
March 2003

Submitted to
City of Morro Bay & Cayucos Sanitary District
San Luis Obispo County
California

By
Earth-Wise/Spirit of the Earth

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Final Report: Executive Summary

The City of Morro Bay and the Cayucos Sanitary District (MBCSD) contracted the services of Earth-Wise/ Spirit of the Earth to conduct a biosolids compost project at the Morro Bay/Cayucos Wastewater Treatment Plant in July 2002.

The goal of the project was to upgrade the biosolids produced at the Morro Bay/Cayucos Wastewater Treatment Plant from class B to class A through composting and the addition of specially formulated compost tea. The project involved monitoring and testing a compost pile consisting of biosolids and green waste from the Cold Canyon landfill.

One part biosolids to four parts green waste by volume were composted following EPA rule (40 CFR Part 503) composting Process to Further Reduce Pathogens (PRFP). After this process was implemented, the compost was inoculated with compost tea. The material was analyzed for pathogens at the start of the project, at three weeks and at seventeen weeks, the end date of the project. Salmonella and E. Coli were used as indicator species to evaluate pathogen density in the composted material.

The project verified that sun drying digested biosolids in drying beds may not be sufficient to ultimately guarantee no pathogen re-growth in the biosolids. While the dried biosolids tested well under EPA standards for pathogens, a re-growth of these pathogens was noted after the EPA (PRFP) process. It is to be noted that the re-growth still tested under EPA standards. The composting material was divided in two piles. One pile received one application of compost tea. The second pile received three applications. With three applications of the compost tea the pathogens were reduced to non-detectable levels and the compost process was hastened by an estimated three to four weeks versus only one application of the compost tea.

The project demonstrated that compost tea, in combination with EPA biosolids composting standards, is an effective means to biologically control regrowth of pathogen in composted biosolids. Based on EPA standards, the compost produced by this project at the Morro Bay and Cayucos Wastewater Treatment Plant was class A for pathogen and well under ceiling levels for EPA 503 risk-based pollutant heavy metals resulting in an Excellent Quality (EQ) biosolids compost. This material, based on EPA standards, can be safely land applied with no restrictions

Introduction

Definition of Terms

Sludge – Primarily human waste product before it is processed by a biodigester at a wastewater treatment plant.

Biosolids – What the sludge is converted to in the biodigester. Biosolids are all liquid/solid products output from the biodigester.

Dried Biosolids – Biosolids that are dried in a drying bed at a waste water treatment plant.

Composted Biosolids – The product that results from composting of biosolids and green waste per EPA rule 40 CFR Part 503.

Compost – Any composted material. For this report this is synonymous with Composted Biosolids. However, not all compost is biosolids based.

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Background and History

The City of Morro Bay and the Cayucos Sanitary District (MBCSD) contracted the services of Earth-Wise/ Spirit of the Earth to conduct a biosolids compost project at the Morro Bay/Cayucos Wastewater Treatment Plant (MBCWWTP) in July 2002. (Funding for the project was also provided by the Integrated Waste Management Authority.)

Currently, the Morro Bay/Cayucos Wastewater Treatment Plant produces 185 wet tons of biosolids per year with a moisture content averaging 17% by weight. The sludge is stabilized through anaerobic digestion in a biodigester and biosolids output is then dried in drying beds at the Morro Bay/Cayucos Wastewater Treatment Plant. The present method of disposal is to truck the dried biosolids to a composting facility in Kern County.

The biosolids produced at the plant is certified as Class B as defined by the US EPA in *The Standards for the Use or Disposal of Sewage Sludge* (Title 40 of the Code of Federal Regulations [CFR], Part 503).

The goal of the project was to upgrade the biosolids produced at the Morro Bay/Cayucos from class B to class A through composting and the addition of specially formulated compost tea. The project involved monitoring and testing a compost pile consisting of biosolids and green waste from the Cold Canyon land fill. After the thermal composting cycle was over, compost tea would be applied to the pile. Pathogen levels were monitored throughout the project.

The upgrade from class B to class A biosolids is dependent on pathogen reduction in the biosolids, mainly E. Coli and Salmonella. In addition to thermal composting, aerobic bacteria, fungi and nematodes added through compost tea would "biologically compost" the biosolids/green waste mix.

Traditional composting techniques to control pathogens utilize high temperatures (131°F minimum) to "pasteurize" the compost. Potential re-colonization of the compost by pathogens using this technique has been documented in the literature and has been demonstrated by Earth-Wise. This potential re-colonization is due to the fact that biosolids have low, beneficial microorganism density and diversity to compete with the pathogens. The high temperatures achieved during composting further reduce the density and diversity of the aerobic, beneficial microorganisms leaving few antagonist organisms to compete with the pathogens.

Earth-Wise/Spirit of the Earth proposes an alternative methodology that would add to the EPA methodology for the Process to Further Reduce Pathogens (PRFP). This methodology uses the traditional windrow composting technique where green waste and biosolids are mixed into windrows. The composting requirements listed in Appendix B of 40 CFR Part 503 require the temperature of the windrow to be maintained at 131°F or higher for fifteen days or longer. During the period when the compost is maintained at or above 131°F, the windrow is turned a minimum of five times. Once the windrow temperature drops to the 80°F range, the compost is inoculated with a highly microbic and fungally diverse compost tea. The windrow is turned to ensure an aerobic environment beneficial for the microbes, fungi and nematodes. Within an aerobic environment the microorganisms out compete the pathogens for the available nutrients thus preventing the potential re-colonization of the pathogens within the sludge/green waste mix. This methodology produces, as an end product, a biologically stable compost, which can be used as an excellent soil supplement.

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Materials and Methods

Materials

All materials for the compost experiment were assembled in one of twelve drying beds at the Morro Bay/ Cayucos Wastewater Treatment Plant in early July 2002.

Green Waste

Green waste was obtained from Cold Canyon landfill located near Arroyo Grande in San Luis Obispo County. The green waste had been shredded at the landfill but was coarse with pieces over three inches in length and more then one inch in diameter. The material was contaminated with plastics and other materials that were not from a green waste origin.

A representative sample of the green waste was sent for analysis to A&L Western Agricultural Laboratories in Modesto, California on July 1, 2002. The report was returned dated July 14, 2002.

The green waste had a carbon to nitrogen ratio of 25:1. Its bulk density was 10.44 pounds per cubic foot. Moisture was 15.97%. Volatile solids were 66.77%. The elemental analysis on a dry base was as follows:

TABLE 1
Green Waste Macronutrients Analysis (percent)

N	P	P_2O_5	K	K_2O	S	Mg	Ca	Na
1.58	0.33	0.76	0.890	1.072	0.320	0.480	1.760	0.180

TABLE 2
Green Waste Micronutrients Analysis (Parts per Million)

Fe	Al	Mn	Cu	Zn
7,889	4,233	182	43	180

Biosolids

Prior to composting, a sample of the biosolids was sent for analysis to A&L Western Agricultural Laboratories in Modesto, California. The results from the analysis were as follows:

- Carbon to nitrogen ratio was 10:1.
- Bulk density was 42.41 pounds per cubic foot.
- Moisture was 14.46%.
- Volatile solids were 45.46%.
- Proportion of ammonia nitrogen was 0.32%.
- Nitrate nitrogen was 0.003%.
- Soluble salts were 18.5 dS/m.

The elemental analysis on a dry base is shown in Tables 3 – 6 that follow:

TABLE 3
Biosolids macronutrients analysis (percent)

N	P	P_2O_5	K	K_2O	S	Mg	Ca	Na
2.63	2.05	4.70	0.200	0.241	1.010	0.550	3.880	0.300

TABLE 4
Biosolids micronutrients analysis(parts per million)

Fe	Al	Mn	Cu	Zn	B
19,780	14,360	194	477	1,276	2,03.0

TABLE 5
Biosolids EPA 503 Risk-Based Pollutant Heavy Metals (mg/kg)

Detection Limit	Analyte	Level Found
0.50	Arsenic	6.80
0.10	Cadmium	4.80
0.50	Chromium	71.30
0.10	Copper	400.30
1.20	Lead	BDL
0.05	Mercury	0.89
1.00	Molybdenum	16.10
0.10	Nickel	39.20
5.50	Selenium	BDL
0.10	Zinc	888.60

TABLE 6
Dry Biosolids Pathogen Report

Total Coliform (MPN/g)	Fecal Coliform (MPN/g)	Salmonella (MPN/4g)
< 2	< 2	< 0.8

The pathogen levels in Table 6 are within the EPA requirements for class A biosolids.

Methods

On July 24th, 1.7 cubic yards of dried biosolids was mixed with 6.7 cubic yards of green waste for a total project volume of 8.4 cubic yards. The proportion by volume was one part biosolids to four parts green waste. The starting weight of green waste was 1,888 pounds. The biosolids weight was 1,946 pounds. The total starting weight of the windrow, prior to hydration, was 3,852 pounds or 1.721 tons.

The mixing of the two materials was done with a front-end loader with a .75 cubic yard bucket. As the loader was mixing the two materials, water was added until the moisture content of the blend was estimated to be between 40 and 50 percent. The moisture content was estimated by the squeeze method—a hand-full of material was squeezed and proper moisture was obtained when a drop of water comes out of the hand-full. When the moisture content and the level of homogeneity of the mix were deemed acceptable, the loader

placed the material in a windrow. The windrow was 22 feet in length, 6 feet in width and 2.6 feet in height. The windrow was covered with shade cloth to protect it from the sun and to reduce evaporation.

July 29th was established as day one of the EPA rule (40 CFR Part 503) for time and temperature requirements. The windrow was managed following the Process to Further Reduce Pathogens (PFRP) where:

- The temperature of the windrow has to be maintained at or above 131°F for at least 15 days.
- During that period of time the windrow has to be turned 5 times.

At the end of fifteen days, a representative sample of the compost was sent to A&L Laboratories for analysis. The analysis included the same constituents as the original biosolids sample.

After the initial two weeks (15 days) of composting to satisfy the EPA time and temperature requirements, the windrow was turned twice weekly for an additional period of four weeks. Moisture was checked at each turning using the squeeze technique. Water was added as needed. Throughout the composting process, temperatures were checked mornings at 10:30 AM in two locations at a depth of twelve inches and twenty-four inches twice weekly prior to turning. Two Reotemp 24-inch stem thermometers were used. Carbon dioxide concentrations were evaluated using a Bacharach 10-5000-combustion test kit. From week seven to week twelve, the windrow was turned weekly and monitored twice per week for temperatures and carbon dioxide concentrations.

Splitting the Windrow into Two Piles

On September 5th, the windrow was divided into two piles. Pile #1 was treated with one application of compost tea. Pile #2 received three applications. The compost tea was produced by Earth-Wise and introduced into the pile prior to turning. The tea had a high concentration and diversity of beneficial, aerobic bacteria fungi, Protozoa and nematodes.

Analysis of the compost tea by Soil Foodweb Inc. in Corvalis, Oregon yielded a total bacterial biomass (ug/mL) of 3,789 with a desired range of 150–300. This means the tea was highly biologically active. The fungal count was reported as low. This was due to loss of live fungi in the sample during shipping to Soil Foodweb Inc.

The two piles continued to be turned and monitored weekly until week twelve of the project. Weeks thirteen through seventeen were used for curing the compost with no turning. A final, representative sample was taken on week seventeen and sent to A&L Laboratories for analysis.

Results

Starting Materials and Initial Mixing

The Cold Canyon green waste was coarse. Many woody pieces were over three inches in length and one inch in diameter. After twelve weeks of composting and five weeks of curing 25% of the volume of the material did not go through a 0.75-inch sieve. This was equivalent to 12% by weight. Contaminants such as plastics, nylon stockings, bottle caps and other objects were also a visual problem.

The front-end loader with a .75 cubic yard bucket was an effective tool to mix the green waste and the biosolids. Initially, it took 1:15 hours of turning and watering before the materials were uniformly distributed. Subsequent turnings and watering of the material took between 30 and 45 minutes.

The shade cloth used as a windrow cover was adequate to protect the windrow from the negative effects of the sun's ultra violet rays. It was not effective for moisture retention with the outer two inches of windrow desiccating excessively between turnings.

Compost Moisture and Water Use

During the seventeen weeks of the project the material was kept between 40% and 45% moisture by weight. At week three of the compost cycle, A&L Laboratories reported a 41% moisture content in the windrow. At week seventeen, the final moisture of the compost was 47.5%.

A total of 426 gallons of water was used to keep the moisture level of the materials above 40% during the twelve weeks of composting. The water requirement to compost one cubic yard of biosolids was 277 gallons.

Windrow Volume and Volume Reductions

The initial volume of the windrow was 8.4 cubic yards. The initial volume of green waste was 6.7 cubic yards. The initial volume of biosolids was 1.7 cubic yards. At week seventeen, the volume of pile #1 was 3.2 cubic yards and the volume of pile #2 was 2.2 cubic yards giving a combined volume of 5.4 cubic yards. Composting the biosolids resulted in a 35% volume reduction.

Bulk Densities

The green waste and biosolids bulk densities were 10.44 pounds per cubic feet and 42.41 pounds per cubic foot respectively. With a 4 to 1 mixing proportion by volume and average moisture content of 15.67%, the bulk density of the mix was 16.83 pounds per cubic foot. When the mix was hydrated to between 40% and 45%, the starting bulk density was 28.38 pounds per cubic foot. A bulk density of 28.37 pounds per cubic foot provides good pile porosity for gas exchange.

At the end of twelve weeks of active composting and with moisture content of between 40% and 45%, the bulk density of pile #1 was 34.39 pounds per cubic foot. The bulk density of pile #2 was 35.45 pounds per cubic foot.

At week seventeen, with moisture content of between 45 and 50%, the bulk density of pile #1 was 41.07 pounds per cubic foot. The bulk density of pile #2 was 40.70 pounds per cubic foot. After twelve weeks of composting and five weeks of curing, the average increase in bulk density was 44%.

Compost Tea Treatments

On August 21st, five gallons of compost tea was applied to the windrow. This occurred before the windrow was split. Pile #2 received two more applications of compost tea. The first application was on September 5th. The second application was two weeks later on September 19th. Each application consisted of fifteen gallons of compost tea.

Carbon to Nitrogen Ratio

The starting carbon to nitrogen ratio was 17:1. After three weeks of active composting the carbon to nitrogen ratio was 12:1. The final carbon to nitrogen ratio of pile #2 was 14:1.

Temperatures

On July 27th, five days after the formation of the windrow, the material was at an average temperature of 152°F at a depth of between twelve and eighteen inches. Day five after windrowing was used as the first day of the EPA regulatory two-week "pasteurization" process. The average temperatures during those two weeks was 140.86°F. (EPA requires a minimum average temperature of 131°F for fifteen days.) In addition, the windrow was turned five times over the two week period as required by the EPA. Daily and average temperatures are shown in the following table:

TABLE 7
EPA 2 Weeks Regulatory Temperature Log

DAY	LOCATION #1	LOCATION #2	AVERAGE
1 (7/27/2002)	150	154	152.0
2	147	150	148.5
3	145	145	145.0
4	135	142	138.5
5	144	148	146.0
6	141	137	139.0
7	150	150	150.0
8	149	142	145.5
9	133	133	133.0
10	133	138	135.5
11	136	138	137.0
12	138	140	139.0
13	138	134	136.0
14	132	136	134.0
15 (8/10/2002)	134	134	134.0
Average Temp			140.86

The average weekly temperatures of the windrow prior to September 5th, when it was separated into two piles were:

- Week #3* of active composting: 134.9 (*Week #3 was after the initial two weeks where EPA composting standards were met.)
- Week #4 of active composting: 117
- Week #5 of active composting: 115.5

From November 5th to December 3rd, temperatures were again recorded. These temperatures were compared to ambient temperatures to evaluate the maturity of the compost. A difference of less than 10°F indicates finished compost. On December 3rd the difference in temperatures in pile #2 (subsequent tea applications after windrow split) was within this parameter, while pile #1 (no tea applications after windrow split) was 20 degrees over ambient.

Carbon Dioxide Concentrations

The concentration of Carbon Dioxide (CO_2) in a compost pile indicates the level of biological activity. A compost pile is considered mature when the level of CO_2 is between three percent and five percent.

Prior to October 1st, CO_2 concentration in the windrow and then in both of the piles was over twenty percent. After October 1st, the concentrations in the two piles were under 20%, the maximum graduation of the Bacharach 10-5000-combustion test kit. The weekly percentages for the CO_2 concentration in the two piles are show in Table 8. The table covers project weeks eighteen through twenty-six.

TABLE 8
Piles Carbon Dioxide Concentrations

Week	Pile #1	Pile #2
10/02 to 10/08	8.0	7.0
10/09 to 10/14	5.5	7.0
10/15 to 10/21	13.0	6.0
10/22 to 10/28	9.0	6.0
10/29 to 11/04	6.0	4.0
11/05 to 11/12	N/A	N/A
11/13 to 11/19	6.5	5.0
11/20 to 11/26	6.0	5.0
11/27 to 12/03	7.5	4.5

Compost Nutrient Analysis

At week three, a sample of the compost from the windrow was sent for analysis to A & L Laboratories. The results were as follows:

- pH: 6.6
- C:N: 12:1
- Soluble Salts = 34.3 dS/m
- Organic Nitrogen = 1.89%
- Ammonia Nitrogen = 0.21%
- Nitrate Nitrogen = .003%

TABLE 9
Compost Macronutrients Analysis, Week 3 (percent)

N	P	P_2O_5	K	K_2O	S	Mg	Ca	Na
2.10	0.96	2.20	0.54	0.65	0.38	0.36	2.36	0.15

TABLE 10
Compost Micronutrients Analysis, Week 3 (parts per million)

Fe	Al	Mn	Cu	Zn	B
13,070	8,355	198	183	644	35

A representative sample of the finished compost taken on week seventeen was sent for analysis to A & L Laboratories. The results were as follows:

- pH: 6.6
- C:N: 14:1
- Soluble Salts = 35.4 dS/m
- Organic Nitrogen = 1.921%
- Ammonia Nitrogen = 0.026%
- Nitrate Nitrogen = 0.0133%

TABLE 11
Compost Macronutrients Analysis, Week 17 (percent)

N	P	P2O5	K	K2O	S	Mg	Ca	Na
1.96	1.32	3.02	0.54	0.65	0.96	0.54	2.87	0.22

TABLE 12
Compost Micronutrients Analysis, Week 17 (parts per million)

Fe	Al	Mn	Cu	Zn	B
21,860	9,387	210	243	718	NA

Heavy Metals

At week three a representative sample was sent to A & L Laboratories to be analyzed for the EPA risk-based pollutants metals. The results were as follows:

TABLE 13
Compost EPA 503 Risk-Based Pollutant Heavy Metals, Week 3 (mg/kg)

Detection limit	Analyte	Level Found
0.50	Arsenic	BDL
0.10	Cadmium	4.50
0.50	Chromium	76.40
0.10	Copper	250.80
1.20	Lead	34.00
0.05	Mercury	0.28
1.00	Molybdenum	3.70
0.10	Nickel	36.30
5.50	Selenium	BDL
0.10	Zinc	596.00

Pathogen Analysis

Pathogen concentrations in pile #2 were followed during the seventeen weeks of composting. Samples were sent to A & L Laboratories for analysis. The results were as follows:

TABLE 14
Pathogen Analysis In Pile #2

	Total Coliform (MPN/gr.)	Fecal Coliform (MPN/gr.)	Salmonella (MPN/4 gr.)
Starting biosolids	< 2	< 2	< 0.8
Compost @ 3 weeks	80	23	9.2
Compost @ 12 weeks (tea)	8	< 2	< 0.8
Compost @ 17 weeks (tea)	< 2	<2	< 0.8

Notice the return to low (virtually non-detectable) pathogen levels subsequent to the application of compost tea.

Discussion

The compost project that took place at the Morro Bay/Cayucos Wastewater Treatment Plant from July 2002 to December 2002 accomplished the stated goal: To biologically control pathogens in the biosolids out of the drying beds and prior to disposal. The composted green waste and biosolids met EPA class A requirements. It took 130 days to complete the composting of the material in pile #2.

Biological Control of the Pathogens

The experiment demonstrated that while the dried biosolids did have a low pathogens count, it appears that the pathogens were physically controlled by a lack of moisture. The biosolids used in the experiment were at 14.46% moisture by weight. At that moisture level, biological activity is, for all practical purposes, at a stand still.

When the moisture in the biosolids is increased above 25% pathogens are reactivated. With moisture levels between 40% and 60%, an oxygen poor environment and a source of available nutrients, the pathogens in biosolids can re-populate. The only limiting factor is the level and type of nutrients available.

Sludge that has been processed through an anaerobic digester, producing biosolids, can demonstrate re-population of pathogens even though the levels are at or below EPA standards for class A biosolids. Biosolids are rich in anaerobic organisms, but poor in beneficial aerobes. Consequently, when such material are brought out of the digester and into an oxygen rich environment, there are too few aerobic organisms to compete for nutrients with the pathogens. In this project the re-growth was analyzed after two weeks of composting at above 131°F and six turnings. It could be speculated that the pathogen load of the material was much higher when hydrated but prior to composting. Table 15 below shows coliform levels at various stages of the project:

TABLE 15
Pathogen Load at Different Stages in the Treatment Process

	Total Coliform (MPN/ml)	Fecal Coliform (MPN/ml)	Salmonella (MPN/ml)
Primary sludge	$1.6 * 10^5$	$1.6 * 10^5$	80
Digested sludge (biosolids)	$3 * 10^3$	400	8
Dried biosolids	< 2	< 2	< 0.8
Compost @ 3 weeks	80	23	9.2
(pile #2 only)	3 applications of	compost tea	starting on week #4
Compost @ 12 weeks	8	< 2	< 0.8
Compost @ 17 weeks	< 2	< 2	< 0.8

To biologically control pathogens, aerobic microorganisms must be introduced to compete with the pathogen for available nutrients. In the experiment performed at the Morro Bay/Cayucos Wastewater Treatment Plant, this was accomplished through composting the material with green waste and subsequently adding compost tea. The compost tea was produced with high quality compost containing a high number and large diversity of beneficial (aerobic) microorganisms. These included bacteria, fungi, protozoa and nematodes. The compost was brewed in a "Earth-Wise" compost tea brewer. The resulting brew was used to inoculate the composting material.

Management of a Full-Scale Compost Project

A full-scale composting project at the Morro Bay/Cayucos Wastewater Treatment Plant would require the management of 1,000 cubic yards of material. This would include 200 cubic yards of biosolids produced annually at the plant and 800 cubic yards of green waste needed as a source of carbon and as a bulking agent. With an expected 35% volume reduction through composting, the final volume of compost would be 650 cubic yards of finished compost.

It took 130 days for pile #2 to reach full maturity. Full maturation was determined when the CO_2 concentration in pile #2 reduced 4.5% and with a temperature differential of less then 10°F between the inside of the pile and ambient temperature. A full-scale project would have to be completed during the dry season. This project would have to accommodate 900 linear feet of windrow 6 feet wide and 5 feet tall. It would be logistically difficult to manage such a project at the treatment plant with the limited amount of space available.

At this point in time, with the ban on land application of biosolids in San Luis Obispo County, Morro Bay would be faced with having to dispose of 650 cubic yards of material out of the county. Currently, 200 cubic yards is being shipped to a composting facility in Kern County.

The above would indicate that immediate implementation of a full-scale compost project at Morro Bay/ Cayucos Wastewater Treatment Plant would not be practical. However, a plan where the cubic yardage of biosolids composted through a number of managed steps is increased over time is a practical and attractive alternative for the treatment plant.

Regulatory Criteria

A full-scale compost project would need a permit from the leading enforcement agency. In San Luis Obispo County, that agency is the County Environmental Health Department. Even smaller projects would need to be permitted. Certain projects can be permitted under an "experimental" permit—this project for example. Once the scope of the composting project has been more fully defined, the appropriate permitting can be investigated and obtained.

Quality of the Produced Compost (Green Waste/Biosolids Mixture)

The results on the quality of the compost produced was good but could be improved. This was mainly due to the low carbon to nitrogen ratio (17:1) used to establish the biosolids to green waste blending ratio. This low C:N ratio was selected to reduce the volume of material as much as possible. The low C:N ratio selected resulted in a final pH of less than seven (6.6). The concentration of ammonia (26 PPM) in the final compost demonstrates a material that is still in its reduction phase. Within the time frame of the project, further composting could have taken place if more carbon had been available.

A good starting carbon to nitrogen ratio would be between 25:1 and 30:1.

Heavy Metals Concentration

There were variations between the EPA 503 risk based pollutant–heavy metals concentrations found in the biosolids and in the compost product. These differences were as follows:

TABLE 16
Comparative EPA 503 Risk-Based Pollutant Heavy Metals (mg/kg)

Analyte	Biosolids	Compost	% change
Arsenic	6.80	BDL	- 100.00%
Cadmium	4.80	4.50	- 6.25%
Chromium	71.30	76.40	+ 7.15%
Copper	400.30	250.80	- 37.35%
Lead	BDL	34.00	+ 100.00%
Mercury	0.89	0.28	- 68.54%
Molybdenum	16.10	3.70	- 77.02%
Nickel	39.20	36.30	- 7.40%
Selenium	BDL	BDL	0.00%
Zinc	888.60	596.00	- 32.93%

The dried biosolids, prior to composting, was under the EPA 503 regulations for heavy metals. The addition of green waste should provide additional dilution of heavy metal concentration. This was shown to be the case.

The concentration in heavy metals in the compost was under the pollutant limits as set by EPA rule 503 for pollutant concentration limits for excellent quality composted biosolids. They were also under the more stringent limits imposed in British Colombia, Canada except for Cadmium and Zinc. Cadmium was 33% above the limit and zinc was 397% above the British Colombia limits. The heavy metals in the compost compare to the two standards as follows:

TABLE 17
Compost EPA 503 Risk-Based Pollutant Heavy Metals Versus EPA 503 and British Columbia (B.C.) Limits (mg/kg)

Analyte	Compost	EPA	B.C.
Arsenic	BDL	41	13
Cadmium	4.5	39	3
Chromium	76.4	1,200	100
Copper	250.8	1,500	400
Lead	34.0	300	150
Mercury	0.28	17	2
Molybdenum	3.7		5
Nickel	36.3	420	62
Selenium	BDL	36	2
Zinc	596.0	2,800	150

Land Application Example Using Alfalfa

The compost produced would make a good soil supplement and can safely be land applied. Following is an example of composted biosolids, meeting the same pathogen and heavy metal levels as that produced during the project, being land applied to alfalfa.

Based on major nutrient utilization for alfalfa, (see Table 18) the following recommendation would satisfy the needs of the crops. The first ceiling nutrient is phosphate. Because the phosphate levels are high in the composted biosolids, applying enough compost to meet the nitrogen requirements for alfalfa would provide too much phosphate. The nitrogen and potash will have to be provided from a different source (see Table 19).

TABLE 18
Alfalfa Major Nutrient Requirements (lb./acre)

Crop	Yield	Nitrogen	Phosphate	Potash
Alfalfa	10 tons	600	120	600

The phosphate in the compost at 60.5 pounds per tons limits the rate of application of the compost to two tons per acre. At this rate the compost would contribute the following:

TABLE 19
Compost Agronomic Value @ 2 Tons per Acre (lb/acre)

	Nitrogen	Phosphate	Potash	Magnesium	Calcium	Sulfur
Requirements	600.0	120	600.0	53.0	280.0	51.0
Compost @ 2 T/acre	78.4	121	26.0	21.6	114.8	38.4
% of requirements	13.0	100	4.0	40.7	41.0	75.3

Based on a 2 tons per acre rate the following amount of heavy metal would be applied per hectare:

TABLE 20
EPA 503 Risk-Based Pollutant Heavy Metals Load (kg/hectare)

Analyte	APLR (*) kilogram / hectare	Compost @ 0.809 tons/hectare
Arsenic	41	BDL
Cadmium	39	3.64
Chromium	3,000	61.81
Copper	3,000	20.29
Lead	300	27.51
Mercury	17	0.27
Molybdenum	No EPA Standard Established	2.99
Nickel	420	29.37
Selenium	100	BDL
Zinc	2,800	482.16

*APLR = Application rate per hectare.

At a rate of 2 tons per hectare or 1,813 pounds per acre all heavy metals are under the limits imposed by EPA. The compost being at 47.5% moisture the amount of compost applied per acre is 3,816.9 pounds or 3.4 cubic yards. Composting the 200 yards of dried biosolids produced at the Morro Bay/Cayucos Wastewater Treatment Plant would provide enough compost to cover a field surface area of 294 acres of alfalfa.

Conclusions and Recommendations

Discussion

Currently the Morro Bay/Cayucos Wastewater Treatment Plant uses anaerobic digesters and drying beds to stabilize the biosolids generated during the treatment process. The present process used to stabilize the sludge is adequate at this time for the efficient operation, and disposal of class B biosolids.

The biosoids presently being produced has a low metals concentration as identified by the US EPA in 40 CFR part 503. In fact, the concentration of heavy metals in the sludge was under the pollutant limits as set by EPA rule 503 for pollutant concentration limits for excellent quality biosolids.

The final compost product demonstrated that a further reduction in metals concentrations occurs during the composting process. The only exception to this, was a slight increase in lead and chromium concentrations. The reason for the increase in these two metals is unknown, the increase either came from contaminated green waste or, possibly, laboratory error.

The metals concentrations in the final compost product were generally below the stringent British Columbia standards imposed for the land application of sludge in Canada. The only exception to this were cadmium and zinc. Cadmium was 33% above the limit and zinc was 397% above the British Colombia limits.

Composting is a proven and acknowledged process for upgrading the quality of sludge through an EPA recognized procedure for Process to Further Reduce Pathogens (PFRP).

The finished compost product can and is being safely used by the public and commercial landscapers as a high quality soil amendment. There are several commercial soil amendments available in the general marketplace which contain a percentage of biosolids.

Project Conclusion

- The pathogen content of biosolids dried in the drying beds is below the EPA standards for class A biosolids. The low moisture content may be responsible for the low pathogen levels.
- The inoculation of the composted biosolids with beneficial aerobic microorganisms contained in the compost tea prevents the re-growth of pathogens.
- The project demonstrates that composting biosolids with green waste, combined with the use of compost tea is an effective way to produce a Class A compost capable of being distributed as Exceptional Quality compost for soil amendment.
- Due to space limitations at the Morro Bay/Cayucos Wastewater Treatment Plant, composting all of the sludge generated annually may not be feasible at this time.

Recommendations

Recommendation 1

Based on the conclusions obtained from the project conducted at the Morro Bay/Cayucos Wastewater Treatment Plant, Earth-Wise/Spirit of the Earth recommends developing a methodology that would allow for composting as the dried biosolids become available. A full-scale project appears beyond the physical capability of the Morro Bay/Cayucos Wastewater Treatment Plant at this time. If it is decided to compost all the biosolids in one batch, composting at a site near the Treatment Plant is a possibility.

Earth-Wise recommends a phased in approach:

- Compost a percentage of the biosolids with green waste keeping the total volume under 250 yards.
- Sell or give away the finished compost to residents, landscapers, or growers for use in the local community.
- Develop a market by demonstrating that the resulting compost is an excellent soil amendment.

Recommendation 2

Earth-Wise recommends further research in the area of applying compost tea directly to the biosolids in the drying beds once the material has reached less than 50% moisture by weight. This would biologically stabilize the biosolids resulting in the production of class A quality biosolids. It would not result in any major increase in labor costs and the equipment costs would be minimal compared with any alternatives available in the industry.

Biosolids treated as recommended could greatly reduce the amount of green waste needed to ensure a high C:N ratio. There are also indications that the composting process can be shortened giving the same results as a full composting/curing cycle.

Recommendation 3

The regulatory requirements for the disposal of Class B biosolids are changing in San Luis Obispo County and counties throughout California. These requirements will likely make the disposal of Class B biosolids more expensive or will prohibit the disposal of Class B biosolids altogether.

Earth-Wise recommends the City of Morro Bay and the Cayucos Sanitary District continue to explore cost-effective methods for upgrading the biosolids at the Morro Bay/Cayucos Wastewater Treatment plant to Class A standards.

Recommendation 4

In addition, Earth-Wise recommends the City and Sanitary District continue to monitor and support the County of San Luis Obispo as they promulgate new regulations for the beneficial reuse of biosolids produced within the County of San Luis Obispo. The City and Sanitary District should support the beneficial reuse of biosolids by working with the County to develop standards that will allow for the safe reuse of the biosolids.